Pedobiologia, Bd. 11, S. 262–268 (1971)

United States Department of Agriculture
Forest Service
Southeastern Forest Experiment Station
Forestry Sciences Laboratory

# Vertical movement of Acarina under moisture gradients

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With one Figure

(Accepted 10. X. 1970)

## 1. Introduction

The moisture content of a substrate determines to a large degree the number of microarthropods present. On several occasions, our samples from the forest floor of loblolly pine (*Pinus taeda* L.) plantations after several weeks of drough yielded very few mites. Two days after wetting a square meter of the floor with 20 liters of water from 5 to 10 times more mites were recovered.

The objective of the work reported here was to study the relationship of the vertical movement of mites to drying and rewetting of the material in which they occur.

## 2. Methods

About 3 kilograms of moist F-layer were collected from the base of several loblolly pine trees in a 40-year-old plantation in Durham County, North Carolina, for each experiment. The F-layer consisted primarily of partially decomposed needles, twigs, and bark, with none of the pieces over 1 cm in length. The material was througly mixed before portions were removed for the experiment. There was a control and three treatments, each replicated five times. Thus, twenty 60-g samples were used in an experiment. The assumption was that there was a comparable number of mites in each sample.

The experiment was repeated four times over a period of six months. Since data of the four experiments were consistent, the results presented are an average of these experiments.

Treatments were established in plastic pots, 17 cm in diameter and 18 cm tall. The bottom 8 cm of each pot was filled with a sandy loam soil, not involved in the experiment, which had been oven-dried at 100 °C. for 48 hours. A piece of plastic window screen, with openings about 1 mm square, was placed on the surface of this filler soil. On this screen were placed two pieces of filter paper separated by a small perforated plastic tube (O. D. = 0.5 mm; I. D. = 0.3 mm). This tube, which extended above the level of the pot, was arranged so that water introduced in it would keep the filter paper damp. On the top layer of filter paper was a 1.3 cm layer of well aggregated sandy loam mineral soil from the $A_1$ horizon (organically enriched surface soil). This soil was air-dried for several weeks and portions placed on Tullgren funnels before the experiment confirmed that no organisms were present.

Above this thin layer of soil was another piece of window screen and on this screen was placed the F-layer material. A diagram of a vertical cross section through the pot is shown in Fig. 1.

The inside top 2 cm of each pot was lined with sticky tape. No mites could be seen on this tape at the end of the experiment and so it appears none escaped from the pots by climbing the sides.

The pots were kept in the laboratory at ambient temperature (ca. 20 °C) in natural daylight but away from direct sunshine, and in darkness during the night.

### 2.1 The treatments

Control: Five of the 20 samples were placed on TULLGREN funnels at the same time the treatments were prepared. After extraction the organic material was oven-dried to constant

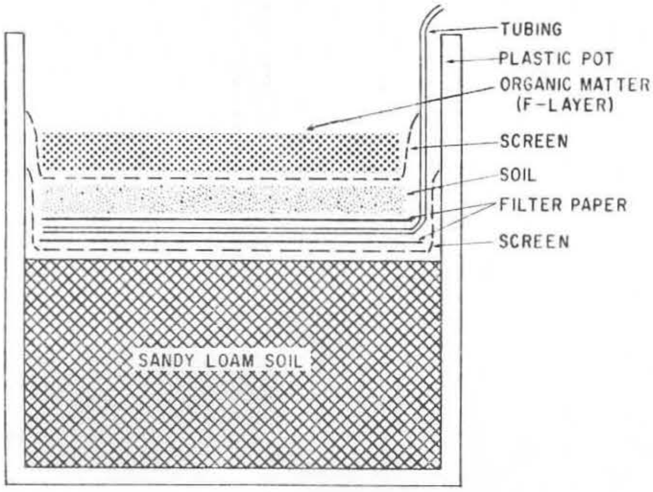


Fig. 1. Vertical cross section of an experimental pot.

weight at 70 °C for moisture content determination. This is not a true control because it did not parallel the treatments in time. It did indicate the number of mites in the treatments at the beginning of the experiment.

Treatment 1: The organic material was kept near the field moisture content by applying each day, as a spray, 33 cc of water to the surface. Since some of this water moved into the mineral soil just beneath the organic material, no water was applied through the plastic tubes. This treatment simulated optimum moisture conditions, with a moist organic layer underlain by a moist mineral soil, to determine how many mites would move vertically without a distinct moisture gradient. The treatment lasted 14 days.

Treatment 2: Organic material was allowed to dry for 14 days while water was added, at the rate of 15 cc per day, through the small plastic tube. This treatment gave a good moisture gradient from the dry surface material to the damp soil. Movement of mites indicated the screen was not restrictive and the dryness of the organic layer indicated there was limited, if any, movement of water up from the damp soil.

Treatment 3: The organic layer was allowed to dry for 14 days as in treatment 2, and then the surface was sprayed for 14 days as in treatment 1. During the drying period, water was added through the plastic tube; when the surface was sprayed, no water was added through the tube. This treatment indicated the number of mites which moved back into damp organic material they earlier had left.

At the end of each treatment (14 days for numbers 1 and 2, and 28 days for number 3), mites were extracted from the organic layer and the 1.3 cm layer of mineral soil by placing the layers on Tullgren funnels for 7 days. The surface cm of the filler soil was also placed on funnels. No mites were extracted from this material, indicating they did not move below the 1.3 cm layer of soil.

## 3. Results and Discussion

### 3.1. General remarks

The average number of mites extracted for the control and each treatment is shown in Table 1. In the control, the Oribatei accounted for 87 % of those recovered, Mesostigmata for 10 %, and Trombidiformes for 3 %.

The number of mites recovered with wetting (treatment 1), drying (treatment 2), and drying-rewetting (treatment 3) progressively decreased. Since few, if any, mites escaped from the experimental containers, it appears that the mites died as time went on. One would expect considerable mortality with drying if the mites did not move down to the damp soil. In treatments 1, 2, and 3, the largest percentage (based on those in the control) of mites recovered were the Mesostigmata as compared to the other mite groups.

Table 1. Summary of mites surviving three moisture regimes

| "Control" | | Treatment 1 (kept wet) | | | Treatment 2 (F-layer dry; soil wet) | | | Treatment 3 (F-layer dried and rewet; soil wet) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F-layer | Soil | Total | F-layer | Soil | Total | F-layer | Soil | Total |
| Oribatei | 762[1] | 599 (*91*)[2] | 59 (*9*) | 658 *86*[3] | 194 (*38*) | 310 (*62*) | 504 *66* | 341 (*76*) | 110 (*24*) | 451 *59* |
| Mesostigmata | 86 | 80 (*94*) | 5 (*6*) | 85 *99* | 30 (*43*) | 39 (*57*) | 69 *80* | 48 (*70*) | 21 (*30*) | 69 *80* |
| Trombidiformes | 24 | 17 (*89*) | 2 (*11*) | 19 *79* | 10 (*53*) | 9 (*47*) | 19 *79* | 9 (*75*) | 3 (*25*) | 12 *50* |
| Total | 872 | 696 (*91*) | 66 (*9*) | 762 *87* | 234 (*40*) | 358 (*60*) | 592 *68* | 398 (*75*) | 134 (*25*) | 532 *61* |

1) Each number is average of twenty (4 experiments with 5 replications per experiment)

2) Percentage, for a single mite group, in the F-layer and soil, for treatments 1, 2 and 3 (values within brackets)

3) Percentage of total number of mites recovered in treatments 1, 2 and 3, as compared to the control.

The continued high survival of this group may be due to their greater mobility which enables them to move from one micro-site to another very quickly.

The movement of mites vertically is evident by comparing the numbers and percentages of mites in the F-layer and the soil for all treatments except the control, where no soil was present.

In the wetting treatment, 91% of the oribatids stayed in the F-layer. When this layer was allowed to dry, the percentage remaining there was 38%; for drying and rewetting, the percentage there increased to 76% of those in the control. These same relationships held for the Mesostigmata and Trombidiformes, and thus for the total of all mites collected.

Table 2 gives the dry weight and moisture content of materials placed on the Tullgren funnels. Although it was possible to begin the various treatments with identical weights of material at field moisture content, slight changes in percentage of water meant that the dry weights differed. The dry weights of both organic and soil layers were so nearly alike in the treatments that it was not necessary to express the number of mites extracted on a unit weight basis for valid comparisons. For the F-layer in treatments 2 and 3, the moisture percentage, 118% and 110% respectively, was a bit lower than the controls because no moisture was added to the samples within 24 hours before they were placed on the funnels.

Table 2. Oven-dry weights and percentage moisture (based on dry weight) when F-layer and soil was placed on TULLGREN funnels

| Treatment | Material | Oven-dry Weight (g) | Water present (%) |
|---|---|---|---|
| Control | F-layer | 31.72 | 134 |
| 1 | F-layer | 30.77 | 118 |
| | Soil | 195.86 | 14 |
| 2 | F-layer | 31.02 | 20 |
| | Soil | 193.16 | 19 |
| 3 | F-layer | 30.78 | 110 |
| | Soil | 193.89 | 19 |

Table 3 shows the relationship between treatments and number of mites recovered for seven species of Oribatei. These species were selected because they were common enough to reveal significant movement but not so abundant as to make counting an extremely time consuming job. There were several dozen species which appeared with less frequency than the seven listed and there were two, *Oppia nova* (OUDEMANS 1902) and *Suctobelba* sp., numbering in the thousands, which occurred in all samples.

### 3.2. Special remarks

#### *Caleremaeus* sp.

Over 90% of the mites of this species recovered in the control were recovered in all other treatments. This indicates the species survived severe changes in moisture content and possible predation. With wetting, 97% stayed in the F-layer and 3% moved into the mineral soil. Of those recovered following drying, 67% stayed in the F-layer and 33% moved into the mineral soil. For the drying-rewetting treatment, the distribution of mites between organic and mineral soil was the same as for the wetting treatment. It appears that if moisture conditions are adequate in both the organic and mineral layers, practically all of this species will stay in the organic layer. If the organic layer dries, about a third of the specimens will move to underlying moist soil. Considering the high

Table 3. Summary of seven species of oribatids surviving three moisture regimes

| Species | Control | Treatment 1 (kept wet) | | | Treatment 2 (F-layer dry; soil wet) | | | Treatment 3 (F-layer dried and rewet; soil wet) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F-layer | Soil | Total | F-layer | Soil | Total | F-layer | Soil | Total |
| *Caleremaeus* sp. | 24.9[1]) | 22.7 (*97*)[2]) | 0.6 (*3*) | 23.3 *94*[3]) | 15.2 (*67*) | 7.6 (*33*) | 22.8 *92* | 21.7 (*96*) | 0.9 (*4*) | 22.6 *91* |
| *Ceratozetes minutissimus* | 54.5 | 46.2 (*84*) | 8.8 (*16*) | 55.0 *101* | 0.1 *0* | 38.8 (*100*) | 38.9 *71* | 16.8 (*51*) | 16.0 (*49*) | 32.8 *60* |
| *Eremobelba* sp. | 5.3 | 4.5 (*84*) | 0.8 (*16*) | 5.3 *100* | 0.5 (*11*) | 4.2 (*89*) | 4.7 *89* | 2.8 (*70*) | 1.2 (*30*) | 4.0 *75* |
| *Oribatula tibialis* | 8.2 | 6.9 (*89*) | 0.9 (*11*) | 7.8 *95* | 7.8 (*94*) | 0.5 (*6*) | 8.3 *101* | 6.9 (*86*) | 1.1 (*14*) | 8.0 *98* |
| *Rostrozetes* sp. | 8.9 | 6.2 (*97*) | 0.2 (*3*) | 6.4 *72* | 1.8 (*24*) | 5.6 (*76*) | 7.4 *83* | 5.5 (*89*) | 0.7 (*11*) | 6.2 *70* |
| *Tectocepheus velatus* | 36.8 | 24.1 (*98*) | 0.6 (*2*) | 24.7 *67* | 13.6 (*65*) | 7.2 (*35*) | 20.8 *57* | 17.5 (*87*) | 2.6 (*13*) | 20.1 *55* |
| *Trhypochthonius americanus* | 8.4 | 6.5 (*84*) | 1.2 (*16*) | 7.7 *92* | 5.4 (*73*) | 2.0 (*27*) | 7.4 *88* | 7.3 (*91*) | 0.7 (*9*) | 8.0 *95* |

1) Each number is average of twenty (4 experiments with 5 replications per experiment)

2) Percentage of mites in the F-layer and soil for one species (values within brackets)

3) Percentage of total number of mites, for one species, recovered in treatments 1, 2, and 3 as compared to the control.

recovery rate, as compared to the control, for the two treatments in which the organic material dried out, relatively few specimens of this species die from temporary drought conditions.

*Ceratozetes minutissimus* (WILLMANN, 1951)

Compared to those mites found in the control, 101% were recovered following wetting, 71% after drying, and 60% after drying and rewetting. With wetting, 84% remained in the F-layer and 16% moved to the soil. Following drying, all moved to the soil and after rewetting about half were in the F-layer and half in the soil. This species seems more sensitive to moisture conditions than the others because all of them moved down into the damp soil when the F-layer was dried and only 60% of the number present in the control survived the drying-rewetting treatment.

*Eremobelba* sp.

This species had the fewest specimens of the seven studied and reacted quite similarly to *Ceratozetes minutissimus*. Following wetting, 16% moved to the soil, after drying 89% were in the soil, and following drying and rewetting 30% stayed in the soil. Following wetting, 100% of those in the control were recovered and this percentage decreased with the other treatments.

*Oribatula tibialis* (NICOLET, 1855)

For the wetting treatment, 95% of those in the control were recovered, following drying 101%, and for drying-rewetting, 98%. Considering the experiment as a whole, this seems to be the most drought-resistant species studied. It also appears to be little influenced by moisture changes; with wetting, 89% stayed in the F-layer, and in the drying and dry-rewetting treatments, 94 and 86%, respectively stayed there.

*Rostrozetes* sp.

The percentage of those in the control recovered in the wetting, drying, and drying-rewetting treatments were 72, 83, and 70%, respectively. The percentages of those extracted for each treatment which stayed in the F-layer were 97, 24, and 89%, respectively. Representatives of this species behaved somewhat like those of *Ceratozetes minutissimus* in that the majority moved to the soil in the drying treatment.

*Tectocepheus velatus* (MICHAEL, 1880)

Members of this species were fairly common in the control but the percentages recovered in the wetting, drying, and drying-rewetting treatments were only 65, 57, and 55%, respectively. This low recovery suggests this species is less hardy than the others. The mites moved between the organic and mineral layers and for the three treatments the percentages recovered in the organic layer were 98, 65, and 87%.

*Trhypochthonius americanus* (EWING, 1908)

The percentages recovered in the wetting, drying, and drying-rewetting treatments were 92, 88, and 95%. The species was not responsive to moisture changes; the percentages recovered in the organic layers for the three treatments were 84, 73, and 91%.

Survival rate, that is, the percentage of mites in the control recovered in the other treatments, was best for *Oribatula tibialis*, *Caleremaeus* sp., and *Trhypochthonius americanus*. Movement of mites in relation to changing moisture levels was greatest for *Ceratozetes minutissimus* and *Eremobelba* sp., followed by *Rostrozetes* sp. and *Tectocepheus velatus*. *Oribatula tibialis* seemed the least influenced by moisture changes.

This experiment emphasizes the importance of moisture when investigating the frequency of mites on a forest site. Since mites move vertically with moisture changes, several centimeters of the surface mineral soil should be sampled along with the organic horizons.

## 4. Acknowledgement

The author wishes to thank Professor Tyler Woolley for assistance in identifying oribatid mites.

## 5. Summary

A laboratory experiment, concerned with survival and movement of mites under different moisture regimes, is described. Groups of mites, as well as seven species of Oribatei were shown to move between mineral soil and organic layers as moisture conditions changed. The Mesostigmata group had a better survival rate than either Oribatei or Trombidiformes. Of the oribatid species studied, *Oribatula tibialis*, *Trhypochthonius americanus*, and *Caleremaeus* sp. had the best survival rates.

## 5. Zusammenfassung

Die vorliegende Arbeit enthält Untersuchungen über die Überlebensrate und Ortsbewegung von Milben unter verschiedenen Feuchtigkeitsbedingungen. In Laborversuchen konnte gezeigt werden, daß sowohl bestimmte Milbengruppen als auch sieben Hornmilben-Arten, je nach den Feuchtigkeitsbedingungen, zwischen Mineralboden und Streuschicht wechseln. *Ceratozetes minutissimus* und *Eremobelba* sp. reagierten am deutlichsten, *Oribatula tibialis* am wenigsten auf Feuchtigkeitsänderungen.

Die Überlebensraten (im Feuchtewechselversuch gegenüber der Kontrolle) erwiesen sich bei den Mesostigmaten höher als bei Oribatiden oder Trombidiformen. Von den untersuchten Oribatiden zeigten *Oribatula tibialis*, *Trhypochthonius americanus* und *Caleremaeus* sp. die höchsten Überlebensraten.

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